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PATENT APPLICATION

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TAKASHI ARAI	)	
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Application No.: 10/634,860	)	
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Filed: August 6, 2003	)	
	:	
For: METHOD OF STORING	)	
MATERIAL INTO WHICH GAS	:	
SATURATES	)	November 30, 2005

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUBMISSION OF SWORN TRANSLATION

Sir:

Applicant hereby submits a sworn English language translation of the Japanese priority application, Japanese Patent Application No. 2002-230323. A certified copy of this priority application was filed on October 6, 2003. Therefore, Applicant respectfully submits that priority has been perfected in accordance with 37 C.F.R. § 1.55.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

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D E C L A R A T I O N

I, Hiroshi Kurokawa, residing at 7 th Fl., Shuwa Kioicho Park Bldg., 3-6, Kioicho, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain correct translation into English of the application document of Japanese Patent Application No. 2002-230323 filed on August 7, 2002, in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed this 29th day of November, 2005.

H. Kurokawa

Hiroshi Kurokawa

Translation of Japanese Patent Application No. 2002-230323

[Type of Document(s)]	Application for Patent
[Reference Number]	4694015
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[Addressee]	Director-General of the Patent Office, Esq.
[International Patent Classification]	B29C 44/00
[Title of The Invention]	METHOD OF STORING MATERIAL INTO WHICH GAS SATURATES
[Number of Claim(s)]	12
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[Detail of Fee(s)]		
[Register Number of Prepayment]	003458	
[Amount of Payment]	21000	
[List of attached documents]		
[Classification]	Specification	1
[Classification]	Drawing(s)	1
[Classification]	Abstract	1
[Number of General Power of Attorney]	0102485	
[Proof Required? Y/N]	Yes	

[Type of the Document] Specification

[Title of the Invention] METHOD OF STORING MATERIAL INTO WHICH GAS SATURATES

[What Is Claimed Is:]

[Claim 1] A method of storing a material into which a gas saturates, before the material is foamed in a metal mold, while maintaining a gas saturated state,

wherein the material into which the gas saturates is stored at a predetermined ambient pressure and predetermined ambient temperature, thereby preventing escape of the gas from the material into which the gas saturates.

[Claim 2] The method according to claim 1, wherein the predetermined ambient pressure is 0.5 to 4 MPa.

[Claim 3] The method according to claim 1, wherein the predetermined ambient temperature is -5℃ to 20℃.

[Claim 4] A method of storing a material into which a gas saturates, wherein a gas is allowed to saturate into a resin material at a saturation pressure P (MPa) of not less than 4 (MPa) and a temperature T (℃), and, letting m $(-0.05 < m < 0.2)$ be a coefficient determined by a material type and a gas saturation time, the material is stored in an ambient defined by a pressure p (MPa) represented by

$$p = P(0.02P + m)$$

and a temperature t represented by

$$0.1875T - 10 < t < 0.5T - 10$$

where $20℃ \leqq T \leqq 60℃$

and represented by

$$0.1875T - 10 < t \leqq 20℃$$

where $T > 60℃$.

[Claim 5] The method according to claim 4, wherein the material is a resin material.

[Claim 6] The method according to claim 4, wherein the material is a rubber material.

[Claim 7] The method according to claim 1, wherein the material is a pelletized solid.

[Claim 8] The method according to claim 1, wherein the gas is an inert gas.

[Claim 9] The method according to claim 8, wherein the inert gas is carbon dioxide.

[Claim 10] The method according to claim 1, wherein a gas saturation amount after storage is 0.1 to 0.4 wt%.

[Claim 11] A method of storing a material into which a gas saturates, wherein 0.1 to 1.5 wt% of supercritical carbon dioxide are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a temperature lower than a gas temperature when the carbon dioxide saturates, and at a high gas density.

[Claim 12] A method of storing a material into

which a gas saturates, wherein 0.1 to 1.5 wt% of supercritical carbon dioxide at a gas density of 0.08 to 0.2 g/cm^2 are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a gas density of 0.7 to 1.0 g/cm^2.

[Detailed Description of the Invention]

[0001]

[Technical Field to Which the Invention Belongs]

The present invention relates to a technique which performs injection foaming or extrusion foaming by allowing a foaming agent such as an inert gas to saturate into a polymer and a rubber material, thereby obtaining a foamed product having a foamed interior.

[0002]

[Prior Art]

Foam foaming has a long history. For example, techniques of obtaining resin foamed products by injection foaming are disclosed in USP3268639 and USP3384691. In recent years, methods of foam foaming using chemical foaming agents or physical foaming agents are described in textbooks of synthetic resin foaming.

[0003]

Lately, a method of foaming a very small foam called a microcell is found in Massachusetts Institute of Technology, U.S.A. This method and an apparatus for

the method are disclosed in USP4473665, USP5158986, USP5160674, USP5334356, USP5571848, and USP5866053. In the method and apparatus proposed in Massachusetts Institute of Technology, U.S.A., a supercritical inert gas is blown into a portion where a resin is melted in a plasticator of an injection foaming machine, and the well-melted resin and the gas are mixed by a static mixer. It was reported that when the pressure and temperature were controlled, a large number of cells of 25 μm or less were evenly dispersed in the foamed foamed product, and the foamed product had almost no strength deterioration since the cell size was small. The above references also describe a method by which a resin material is placed in a pressure vessel, a supercritical inert gas is allowed to saturate into the resin material, and the resin is foamed by abruptly reducing the pressure at a temperature near the melting temperature of the resin, and a method by which the resin is foamed by abruptly raising the temperature after the temperature and pressure are once lowered.

[0004]

Japanese Patent Laid-Open Nos. 8-85128 and 8-85129 describe methods by which a pressure-resistant chamber is attached to a hopper of an injection foaming machine, and a gas is allowed to saturate into a molten resin or resin pellets at a high pressure, thereby foaming the resin.

[0005]

That is, the conventional foam foaming is roughly classified into chemical foaming and physical foaming. The chemical foaming includes a master batch method in which a foaming agent which causes a chemical reaction by heat and a resin material are mixed in the form of pellets, and a method in which the foaming agent is kneaded in a resin material. The physical foaming includes a method in which an inert gas is allowed to directly saturate into a molten resin from a plasticator of an injection foaming machine or extruder, and a batch method in which an inert gas is allowed to saturate into a previously foamed and shaped resin product at a high temperature and high pressure, and the resultant material is foamed in a pressure vessel by abruptly changing the temperature or pressure.

[0006]

[Problems That the Invention Is to Solve]

In the conventional chemical foaming, the master batch method by which a heat decomposable foaming material and a resin material are mixed immediately before foaming is often used. Unfortunately, this method has many problems such as harmfulness, mold corrosion, the worsening of the foaming environment, and the difficultly of handling. In contrast, the physical foaming is harmless and causes no mold corrosion, and nitrogen and carbon dioxide exist in

natural air. Therefore, the physical foaming is regarded as superior to the chemical foaming. However, in the method of allowing an inert gas to saturate directly into a molten resin, the gas is directly blown into the molten resin material, so a portion of the molten resin in contact with the gas is rapidly cooled when the gas is blown. If the gas is continuously blown, a large portion of the molten resin is cooled. Consequently, the viscosity rises, and it takes a long time to restore the resin temperature and viscosity suited to foaming.

[0007]

Also, when a gas is heated to a temperature close to the melting temperature of a resin in advance, the volume of the gas increases with the temperature rise. Therefore, if the gas is directly blown into the molten resin, the foaming magnification after the resin is charged into a foam significantly decreases because the internal pressure of the resin is low.

[0008]

Furthermore, to compensate for this drawback, it is possible to raise the pressure together with the gas temperature, and blow the gas into the molten resin while the gas concentration is maintained. In this method, however, the gas pressure is very high, and the gas flows into the molten resin at the moment when the gas is blown into it. This makes it difficult to

control the gas blowing amount, and increases variations in amount of the gas which saturates into the resin. Also, since the gas is abruptly blown into the molten resin, the molten resin forms two separated layers of the gas and resin near the blowing port. To evenly disperse the gas in the resin, therefore, it is necessary to mechanically repeat kneading by using a static mixer or the like, and encourage dissolution of the gas into the resin by raising the pressure of the resin-gas mixture itself. This complicates the apparatus, and variations in gas saturation amount in the material vary the dimensional accuracy of the foamed product and deteriorate the product quality. In addition, the long cycle deteriorates the productivity.

[0009]

The batch method using an inert gas eliminates both the drawbacks of the chemical foaming and the drawbacks of the physical foaming by which a gas is directly blown into a molten resin. However, since this batch method is an intermittent production method using batch processing, the productivity significantly worsens.

[0010]

A method such as described in Japanese Patent Laid-Open No. 8-85128 in which a gas is allowed to saturate into a resin material by the batch method and then the material is continuously foamed by an

injection foaming machine compensates for the above-mentioned drawbacks. However, the amount of gas which saturates into a solid resin material such as pellets changes in accordance with the gas pressure, temperature, and time. Accordingly, if the foaming cycle or gas saturation time changes even slightly, the amount of gas which saturates into a resin material changes. Since this changes the foamed state of the foamed product, the accuracy also changes.

[0011]

The present invention, therefore, has been made in consideration of the above situation, and has as its object to obtain a high-accuracy foamed product with high productivity.

[0012]

[Means of Solving the Problems]

To solve the above problems and achieve the object, according to the present invention, there is provided a method of storing a material into which a gas saturates, before the material is foamed in a metal mold, while maintaining a gas saturated state, wherein the material into which the gas saturates is stored at a predetermined ambient pressure and predetermined ambient temperature, thereby preventing escape of the gas from the material into which the gas saturates.

[0013]

The method of storing a material into which a gas

saturates according to the present invention further characterized in that the predetermined ambient pressure is 0.5 to 4 MPa.

[0014]

The method of storing a material into which a gas saturates according to the present invention further characterized in that the predetermined ambient temperature is -5℃ to 20℃.

[0015]

According to the present invention, there is provided a method of storing a material into which a gas saturates, wherein a gas is allowed to saturate into a resin material at a saturation pressure P (MPa) of 4 (MPa) or more and a temperature T (℃), and, letting m ($-0.05 < m < 0.2$) be a coefficient determined by a material type and a gas saturation time, the material is stored in an ambient defined by a pressure p (MPa) represented by $p = P(0.02P + m)$ and a temperature t represented by $0.1875T - 10 < t < 0.5T - 10$ where $20℃ \leqq T \leqq 60℃$ and represented by $0.1875T - 10 < t \leqq 20℃$ where $T > 60℃$.

[0016]

The method of storing a material into which a gas saturates according to the present invention further characterized in that the material is a resin material.

[0017]

The method of storing a material into which a gas

saturates according to the present invention further characterized in that the material is a rubber material.

[0018]

The method of storing a material into which a gas saturates according to the present invention further characterized in that the material is a pelletized solid.

[0019]

The method of storing a material into which a gas saturates according to the present invention further characterized in that the gas is an inert gas.

[0020]

The method of storing a material into which a gas saturates according to the present invention further characterized in that the inert gas is carbon dioxide.

[0021]

The method of storing a material into which a gas saturates according to the present invention further characterized in that a gas saturation amount after storage is 0.1 to 0.4 wt%.

[0022]

According to the present invention, there is provided a method of storing a material into which a gas saturates, wherein 0.1 to 1.5 wt% of supercritical carbon dioxide are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a temperature lower than a gas

temperature when the carbon dioxide saturates, and at a high gas density.

[0023]

According to the present invention, there is provided a method of storing a material into which a gas saturates, wherein 0.1 to 1.5 wt% of supercritical carbon dioxide at a gas density of 0.08 to 0.2 g/cm^2 are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a gas density of 0.7 to 1.0 g/cm^2.

[0024]

[Embodiments]

A preferred embodiment of the present invention will now be described in detail in accordance with the accompanying drawings.

[0025]

Fig. 1 is a view showing an apparatus of an embodiment of the present invention.

[0026]

In Fig. 1, reference numeral 1 denotes a vessel; 2, an agitator; 3, a high pressure gas generator; 4, a cooling medium controller; 5, a heater; and 6, a heater controller.

[0027]

Fig. 2 is a view showing the internal structure of the vessel 1 shown in Fig. 1.

[0028]

In Fig. 2, reference numeral 7 denotes a pipe in which a cooling medium circulates; and 8, agitating blades. In the vessel 1, a solid material into which an inert gas as a foaming agent saturates is agitated by the agitating blades 8 connected to the agitator 2, and cooled by the cooling medium which is controlled at a predetermined temperature by the cooling medium controller 4 and circulates in the pipe 7. Also, an inert gas pressurized to a predetermined pressure by the high pressure gas generator 3 is filled into the vessel 1. The heater 5 is installed outside the vessel 1, and the heater controller 6 controls the temperature of the vessel 1.

[0029]

Fig. 7 is a view showing the first example according to the embodiment.

[0030]

The first example will be explained below with reference to Fig. 7.

[0031]

As resin materials, three types (A, B, and C) of high-impact polystyrene (HIPS) were used. Carbon dioxide was used as an inert gas as a foaming agent. Fig. 7 shows the saturation pressure, saturation temperature, and saturation time by which the carbon dioxide was allowed to saturate into the resin material, and also shows the storage pressure and storage

temperature of this example.

[0032]

The storage time in Fig. 7 means the time elapsed since the pressure and time were controlled to the storage pressure and storage time of this example after gas saturation. The weight change is a change ratio calculated by comparing the weight when five minutes elapsed in atmosphere after gas saturation was complete with the weight measured in atmosphere after the material was stored at the storage pressure and storage temperature of this example, i.e., after the storage time elapsed.

[0033]

The storage time and weight change in Fig. 7 indicate that a change in amount of gas which saturated into the resin material was 1% or less even after the storage time elapsed, i.e., there was almost no change in gas amount.

[0034]

That is, when a resin material into which a gas saturates is stored under the storage conditions of this example, escape of the gas from the resin material can be decreased to a very small amount.

[0035]

Practical storage conditions are as follows. A gas is allowed to saturate into a resin material at a saturation pressure P (MPa) of 4 (MPa) or more and a

temperature T (℃). After that, letting m ($-0.05 < m < 0.2$) be a coefficient determined by the material type and the gas saturation time, the resin material is stored in an ambient defined by a pressure p (MPa) represented by

$$p = P(0.02P + m)$$

and a temperature t represented by

$$0.1875T - 10 < t < 0.5T - 10$$

where 20℃ $\leqq$ T $\leqq$ 60℃

and represented by

$$0.1875T - 10 < t \leqq 20℃$$

where T > 60℃.

[0036]

Also, the gas saturation amount after storage is 0.1 to 0.4 wt%.

[0037]

More specifically, 0.1 to 1.5 wt% of supercritical carbon dioxide are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a temperature lower than the gas temperature when the carbon dioxide saturates and at a high gas density.

[0038]

Alternatively, 0.1 to 1.5 wt% of supercritical carbon dioxide at a gas density of 0.08 to 0.2 g/cm^2 are allowed to saturate into a pelletized solid resin material, and the solid resin material is stored at a

gas density of 0.7 to 1.0 g/cm^2.

[0039]

Fig. 5 shows the foamed state of the section of a foamed product obtained by injection foaming after stored for 1 hr by the control method of this example. Fig. 6 shows the foamed state of the section of a foamed product obtained by injection foaming after left to stand for 1 hr without using the present invention. It is readily understood from comparison of Figs. 5 and 6 that the control method of this example is very effective in maintaining the foamed state.

Fig. 8 is a view showing the second example according to the embodiment.

[0040]

The second example will be explained with reference to Fig. 8.

[0041]

Resin materials were six types of materials, i.e., high-impact polystyrene (HIPS), an alloy material (PC/ABS) of polycarbonate and acrylonitrile_butadiene-styrene, polyphenylene ether (PPE), a resin (PPE + GF) formed by filling polyphenylene ether with a glass filler, a resin (PPE + PS) formed by mixing a glass filler in an alloy of polyphenylene ether and polystyrene, and polycarbonate (PC). Carbon dioxide was used as an inert gas as a foaming gas. Fig. 8 shows the saturation pressure,

saturation temperature, and saturation time by which the carbon dioxide was allowed to saturate into the resin material, and also shows the storage pressure and storage temperature of this example.

[0042]

The storage time and weight change shown in Fig. 8 reveal that when the storage pressure and storage temperature were adjusted within the range of this example by the resin material and saturation time, a change in amount of gas which saturated into the resin material was decreased to 1% or less even when the storage time elapsed.

[0043]

Fig. 3 shows changes in weights of HIPS materials at atmospheric pressure and room temperature after an inert gas was allowed to saturate into the materials by the conventional method. For the sake of convenience of measurement, a point five minutes after gas saturation is set to 0. As shown in Fig. 3, at any saturation pressure and any temperature, the gas escaped from the material with time.

[0044]

Fig. 4 shows an example in which the apparatus of this embodiment is used as a hopper of an injection foaming machine.

[0045]

In Fig. 4, reference numeral 9 denotes an

injection foaming machine; 10, a metal mold; 11, a plasticator; 12, a hopper of this embodiment; 13, a gas cylinder; 14, a gas pressurizing apparatus; 15, a gas saturation vessel; 16 and 17, pumps; 18, a material silo; and 19, a pipe. The hopper 12 has the structures shown in Figs. 1 and 2.

[0046]

The foaming process will be described with reference to Fig. 4.

[0047]

A pelletized resin material is stored in the material silo 18. When foaming is to be performed, a necessary amount of the resin material is supplied to the gas saturation vessel 15 by the pump 17. A gas as a foaming material is supplied from the gas cylinder 13 to the gas saturation vessel 15 after pressurized by the gas pressurizing apparatus 14. The gas saturates into the resin material in the gas saturation vessel 15. This resin material into which the gas saturates is supplied to the hopper 12 by the pump 16. In the hopper 12, the resin material into which the gas saturates is stored at the pressure and temperature of this embodiment. In addition, the resin material is supplied to a material feeder of the plasticator 11, plasticized and kneaded, and charged into a cavity having a desired shape in the metal mold 10. The resin into which the gas as a foaming material saturates

starts foaming at the same time the resin is charged into the mold. After cooling, the mold is opened to extract the foamed product.

[0048]

As described above, an inert gas such as carbon dioxide or nitrogen was allowed to saturate into a solid polymer material, and the material was stored at the pressure and temperature of this embodiment. This made it possible to always maintain a predetermined gas saturated state. Accordingly, when this embodiment was used as a hopper of an injection foaming machine or extruder, it was possible to always supply a material having a stable gas saturation amount. Resin foaming and foamed products using this embodiment are harmless to the environment and superior in dimensional stability and productivity.

[0049]

In the above embodiment, foam foaming of resin materials is explained. However, the present invention is of course applicable not only to resin materials but also to rubber materials and so-called polymer materials.

[0050]

In the examples shown in Figs. 7 and 8, the storage pressure was set at 1 to 2.5 MPa. In practice, however, the effect of the present invention can be obtained when the storage pressure is set at 0.5 to 4

MPa.

[0051]

Also, the storage temperature was set at -3℃ to 15℃ in the examples shown in Figs. 7 and 8. In practice, however, the effect of the present invention can be obtained when the storage temperature is set at -5℃ to 20℃.

[0052]

[Effect of the Invention]

As has been explained above, high-accuracy foamed products can be obtained with high productivity by the present invention.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a view showing an apparatus of an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a view showing the internal structure of a vessel 1 shown in Fig. 1.

[Fig. 3]

Fig. 3 is a graph showing changes in weights of HIPS materials at atmospheric pressure and room temperature after an inert gas is allowed to saturate into the materials by the conventional method.

[Fig. 4]

Fig. 4 is a view showing an example in which the apparatus of this embodiment is used as a hopper of an

injection foaming machine.

[Fig. 5]

Fig. 5 is a view showing the foamed state of the section of a foamed product obtained by injection foaming after stored for 1 hr by a storage method of this embodiment.

[Fig. 6]

Fig. 6 is a view showing the foamed state of the section of a foamed product obtained by injection foaming after left to stand for 1 hr without using the present invention.

[Fig. 7]

Fig. 7 is a view showing the first example of the embodiment.

[Fig. 8]

Fig. 8 is a view showing the second example of the embodiment.

[Description of the Reference Numerals]

1 vessel

2 agitator

3 high pressure gas generator

4 cooling medium controller

5 heater

6 heater controller

7 pipe in which a cooling medium circulates

8 agitating blades

9 injection foaming machine

10 metal foam

11 plasticator

12 hopper

13 bombe

14 gas pressurizing apparatus and temperature control apparatus

15 gas saturation vessel

16, 17 pumps

18 material silo

19 pipe

[TYPE OF DOCUMENT] DRAWINGS

FIG. 1

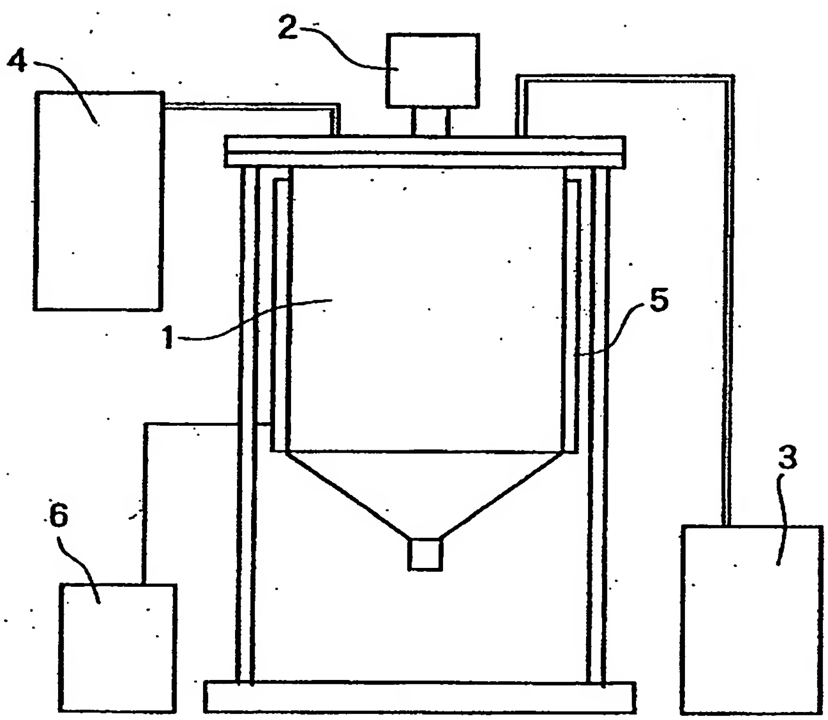


FIG. 2

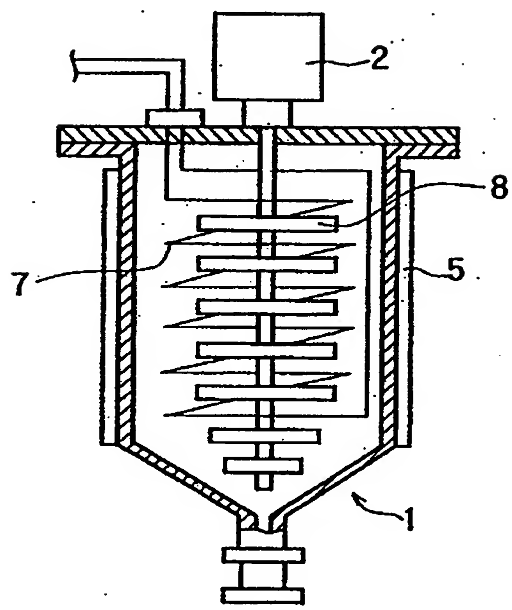
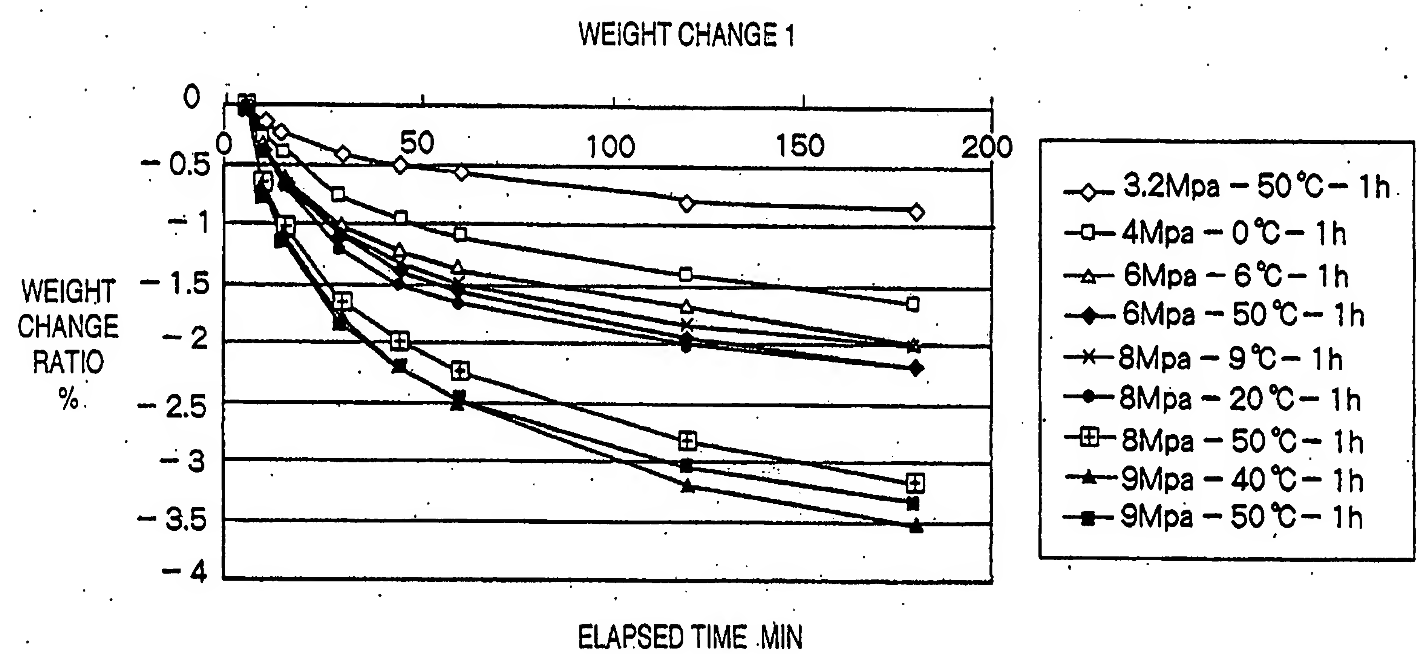


FIG. 3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WEIGHT CHANGE RATIO %
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-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
0
50
100
150
200
ELAPSED TIME MIN
3.2Mpa - 50℃ - 1h
4Mpa - 0℃ - 1h
6Mpa - 6℃ - 1h
6Mpa - 50℃ - 1h
8Mpa - 9℃ - 1h
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9Mpa - 50℃ - 1h

FIG. 4

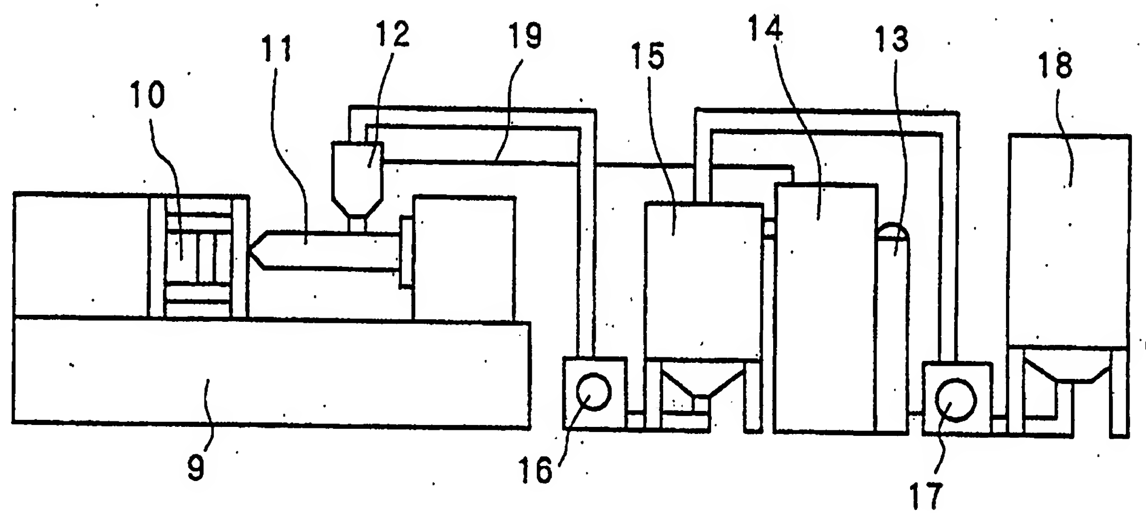

FIG. 5

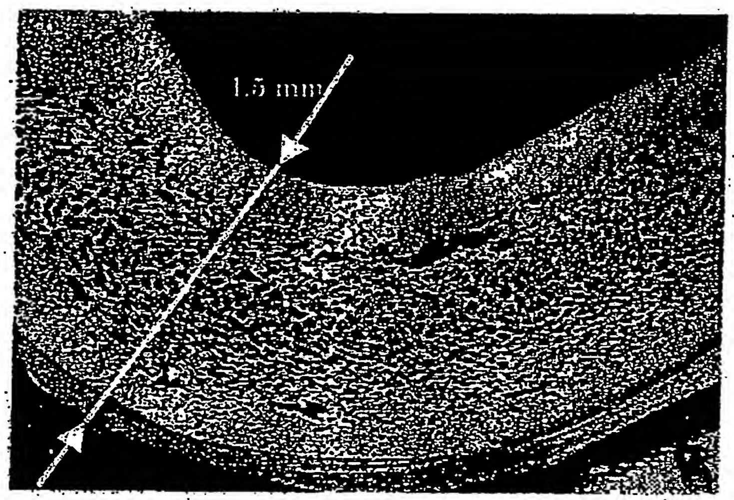

FIG. 6

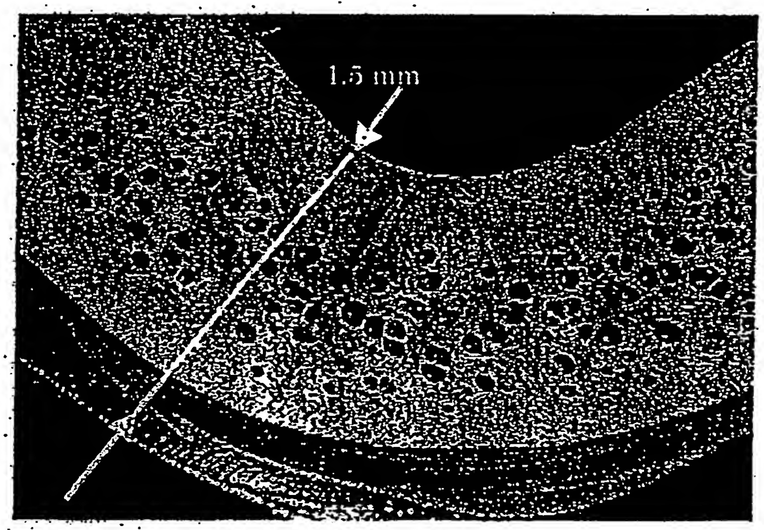

FIG. 7

	HIPS (A)	HIPS (B)	HIPS (A)	HIPS (A)	HIPS (C)	HIPS (A)	HIPS (A)
FOAMING AGENT	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2
SATURATION PRESSURE Mpa	6	6	8	8	8	8	9
SATURATION TEMPERATURE °C	50	50	20	50	50	50	40
SATURATION TIME h	1	1	1	1	1	2	1
STORAGE PRESSURE Mpa	1	1	1.2	1.6	1.6	2	2.5
STORAGE TEMPERATURE °C	10	10	−3	5	5	7	4
STORAGE TIME h	0.5	1	1	1	2	1	1
WEIGHT CHANGE %	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%

FIG. 8

	HIPS (A)	HIPS (A)	PC / ABS	PPE	PPE + GF	PPE + PS	PC
FOAMING AGENT	CO_2	N_2	CO_2	CO_2	CO_2	CO_2	N_2
PERMEATION PRESSURE Mpa	8	8	8	8	8	8	9
PERMEATION TEMPERATURE °C	50	50	50	50	50	50	50
PERMEATION TIME h	1	1	1	1	1	1	1
STORAGE PRESSURE Mpa	1.5	2.4	1.2	1.8	2	1.8	2
STORAGE TEMPERATURE °C	5	3	−3	7	15	3	10
STORAGE TIME h	1	1	1	1	2	1	1
WEIGHT CHANGE %	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%

[Type of the Document] Abstract

[Abstract]

[Problem] It is an object of this invention to obtain a high-accuracy foamed product with high productivity.

[Solving means] To achieve this object, a method of storing a material into which a gas saturates, before the material is foamed in a metal mold, while maintaining the gas saturated state is disclosed. This method stores a material into which a gas saturates at a predetermined ambient pressure and predetermined ambient temperature, thereby preventing escape of the gas from the material into which the gas saturates.

[Selected Drawing] Fig. 7